HEMATITE FUEL FABRICATION FACILITY
(Hematite Former Fuel Cycle Facility)
(Westinghouse Electric Comapany Hematite Facility)
3300 State Road P
Festus
Jefferson County
Missouri

HAER MO-113
MO-113

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
U.S. Department of the Interior
1849 C Street NW
Washington, DC 20240-0001

HISTORIC AMERICAN ENGINEERING RECORD

HEMATITE FUEL FABRICATION FACILITY

HAER No. MO-113

Location:

3300 State Road P
Festus, Jefferson County, Missouri
UTM: 15 720983E 4232032N (Center Point of Complex)
USGS Topographic Map: Festus

Date of Construction:

Mallinckrodt Chemical Works began construction of a uranium fuel fabrication facility near Festus, Missouri, in 1956. The initial Hematite Complex was comprised of Buildings 240, 250, and 235. In 1959 Buildings 255 and 252 were built and in 1968 Building 260 was completed. Building 110 was added to the complex in 1970. In 1989 Combustion Engineering began a construction plan that would enclose the Facility under one roof. This undertaking created Buildings 253 and 256, Buildings 250 and 251 were encapsulated in Building 256. In 1992 Building 230 was added to the Facility and in 1997 Building 231 was built. The final building added to the Facility complex was Building 115.

Designer/Fabricator:

Unknown

Present Owner:

Westinghouse Electric Company Limited Liability Corporation (LLC).

Present Use:

This building complex currently produces uranium fuel and packages the fuel into the rods and rod bundles.

Significance:

The Hematite Fuel Fabrication Facility, also known as Hematite Former Fuel Cycle Facility and the Westinghouse Electric Company Hematite Facility, was constructed over a period of thirty-one years. The Facility was the first privately owned and operated uranium fuel production plant in the United States. The plant produced nuclear fuel for military as well as peacetime purposes throughout the “Cold War” era.

The Hematite Fuel Fabrication Facility produced high-enriched nuclear fuel for the U.S. Navy nuclear submarine program and other reactor programs during the “Cold War” years of 1956 to 1974. After 1974 the Facility produced only commercial grade low enriched uranium for commercial nuclear power facilities.

atomic research. Three federal installations were built at various sites throughout the U.S. for the sole purpose of creating the ultimate weapon. The first site chosen was Oak Ridge, Tennessee; this facility produced Uranium 235 from natural uranium. The Hanford Facility, located in the State of Washington, extracted plutonium from irradiated material, and the last facility built was in Los Alamos, New Mexico, where research and production of the atomic bomb was carried out.

Although President Roosevelt issued the approval to begin scientific research for the creation of the atomic bomb, by the time the decision to use atomic weapons came, the responsibility rested with President Harry Truman. He issued the order to deploy the bombs, and on August 6, 1945, two bombs were released over Japan. One was released over Hiroshima and the other over Nagasaki, thus ending World War II. Although the war had ended, America entered into an arms race with the Soviet Union that spanned four decades and created serious situations involving the threat that nuclear weapons would be used. This period in U.S. history is commonly known as the Cold War.

The U.S. government had many decisions to make regarding the nuclear issue, and in July 1946 the McMahon bill was enacted. Jacques Leclerq, in his book *The Nuclear Age,* makes clear the government's position regarding the use of nuclear fuel. Through the "Atomic Energy Act of 1946, Congress ensured the continued military development of nuclear energy while establishing a legal framework for industrial applications."[4] The McMahon bill also provided for the creation of a commission of five members, which became known as the Atomic Energy Commission (AEC). Gerard Clarfield and William Wiecek in their book, *Nuclear America,* describe in detail the role the AEC would undertake with regards to nuclear materials, saying "the AEC was the owner of all fissionable material to be produced in the future, as well as all existing nuclear facilities . . . The AEC could, however, license private organizations to produce fissionable material . . . the statute prohibited the issuance of any patents on nuclear inventions, and dissolved all existing patents."[5] The statutes set forth in the Atomic Energy Act of 1946 remained in place until 1954 "after President Eisenhower had convinced Congress to pass an amendment restricting the domain reserved for the AEC to nuclear weapons and breaking the federal monopoly on fissile material production plants."[6] President Eisenhower created the "Atoms for Peace" program putting nuclear energy into the realm of civilian industry.

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[4] Jacques Leclercq, *The Nuclear Age: The World of Nuclear Power Plants* (n.p. LeChene, 1986), 28.

[5] Gerard H. Clarfield and William M. Wiecek, *Nuclear America: Military and Civilian Nuclear Power in the United States, 1940-1980* (New York: Harper & Row, 1984), 29.

[6] Leclercq, *The Nuclear Age*, 28.

History of the Hematite Fuel Fabrication Facility

By 1954 the AEC had developed peacetime uses for nuclear energy as well as the military uses that had thus far been developed. Nuclear-powered reactors that could produce electricity became a highly probable use for the uranium that was being produced. Edward Mallinckrodt had already proven that his company could be depended upon to work with fissile material. In January 1956 MCW entered the commercial uranium industry with the formation of the Special Metals Division, and by doing so became the first U.S. privately owned and operated nuclear production facility. The site chosen for the Facility was located near Festus, Missouri, approximately forty miles south of Saint Louis.

The Facility continued to operate under Mallinckrodt Chemical Works until "January 2, 1959 [when] the business and facilities of the nuclear fuels division of the company, including all of the facilities located at Hematite, Missouri, were transferred to Mallinckrodt Nuclear Corporation, a wholly owned subsidiary of the company."[7] In September 1960 Mallinckrodt Nuclear Corporation was liquidated and all assets and business were transferred back to the parent company, Mallinckrodt Chemical Works. At that time, operations at the Facility and Weldon Springs, Missouri, (which was run by MCW for the Atomic Energy Commission) formed the "Nuclear Division" within MCW.

Although the Facility was producing 80 tons of uranium concentrates per day, revenues were not as high as had been anticipated. This was due in large part to the slow start commercial reactors were having in the United States. In an effort to continue producing uranium and generate adequate revenue, Mallinckrodt Chemical Works, Olin Mathieson Chemical Corporation, and Nuclear Development Corporation of America merged to form one company named United Nuclear Corporation (UNC). The Facility operated under the name United Nuclear Corporation from May 31, 1961 through April 1, 1962 at which time UNC merged again, this time with Sabre-Pinion Corporation, but continued to operate under the United Nuclear Corporation name for the next nine years.

In 1970, Gulf Nuclear Fuels Corporation acquired the Facility through a joint venture with UNC; at this time Gulf United Nuclear Fuels Corporation (Gulf) was formed. Gulf sold the Facility to Combustion Engineering Corporation in 1974. Combustion Engineering Corporation owned and operated the plant until 1989 at which time Asa Brown Boveri purchased the Facility in a stock buy-out and operated under the name ABB Combustion Engineering until April of 2000. In April of 2000 Westinghouse Electric Company, LLC (Westinghouse), purchased the nuclear operations of ABB which included the Hematite Facility, and in 2001 Westinghouse ceased all operations in preparation the decommissioning and demolition of the Facility.

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[7] MCW News, *"Hematite Revisited: The Men From Mechanical,"* Vol.3, No. 2 (February-March 1959), 4.

The Facility received enriched Uranium Hexaflouride UF6 primarily from Oak Ridge, Tennessee. There were three levels of uranium enrichment, low-enrichment, which contained five percent or less of Uranium 235, intermediate-enrichment, which contained five to nineteen percent Uranium 235, and high-enrichment, which contained twenty to 100 percent Uranium 235. The low-enriched uranium was used for the production of commercial grade reactor fuel and the intermediate and high-enriched uranium was for government related projects. Although the enrichments are different, the process is the same for all three enrichment grades. Chester Placek, in an article written for the Industrial and Engineering Chemistry publication, describes the process that the product goes through to become fuel.

> "A UF6 cylinder is heated by a steam or hot water jacket. UF6 vapor flows from the cylinder through a dry, stainless steel line into a stainless steel tank containing aqueous ammonia. Flow of UF6 into tank is measured on a rotameter . . . as the fluoride reacts with ammonia, a yellow precipitate of ammonia diurinate (ADU) forms. Precipitation rates and particle size are the two variables most rigidly controlled at this step. Heat reaction during the ADU precipitation is removed with a heat exchanger. Source of the heat is predominately the reaction of the byproduct hydrogen fluoride and ammonium hydroxide. A half hour to 90 minutes is needed to precipitate one full batch of ADU---time depends on the size of the batch. From the precipitation tank, the ADU slurry is transferred to a holding tank of the same size. From here, the slurry is sent to a plate-and-frame filter; ammonium fluoride solution is piped to storage tanks for eventual disposal and the yellow ADU is spread out on drying trays. The trays are put into two electric ovens, and the precipitate is dried at 350 [degrees Fahrenheit]. Exhausts from this hood go through a scrubber before being released into the atmosphere. The dry ADU cake is then portioned into steel 'reactor' boxes measuring 2 x 2 x 5 feet. These are placed into electrically heated furnaces which are heated at 800 [degrees Celsius] for 6.5 hours. At this temperature, ADU decomposes to formU3O8 ammonia and water. Reduction of U3O8 to UO2 is done in the same furnace on the last portion of the cycle. During reduction, ammonia is blown into the furnace and cracked to give hydrogen. This ammonia cracking is done continuously. Maximum amount of oxide in the furnace at any one time is 150 pounds (for low-enrichment only). After reduction, UO2 is cooled in a cooling box (fabricated by Mallinckrodt Chemical Works) under nitrogen. The cooled oxide is milled in a micropulverizer to make powder. Powder from several batches is blended. The mixing technique calls for taking one tenth of the

> contents of ten different drums and blending these fractions into individual drums of product."[8]

The Facility entered into contracts to produce nuclear fuels of various enrichments for corporations such as General Electric, Babcock and Wilcox, and the Atomic Energy Corporation, who in turn held government contracts for the propose of producing nuclear powered material and equipment for the U.S. military. Although it appears that the Facility did not enter into any government contracts as the prime contractor (information continues to be classified and is not currently available) they were still obliged, under federal law, to adhere to AEC regulations.

The Facility operated under licenses issued by the AEC. The Facility held licenses for "Special Nuclear Material" which allowed the Facility to accept and process enriched uranium, a "Source Material License" for natural uranium, and a license for isotopes of Californium and Americium, which was used for the calibration of instruments.[9] Under the licensing regulations the AEC required that plans be developed, written and implemented for all major aspects of the operation. These plans were developed for "Physical Protection," "Accountability" (a plan which outlined the control of the uranium in the Facility), "Health Physics Plan," the "Nuclear Safety Plan," and the "Emergency Plan." When the AEC conducted inspections, they used these plans to determine issues of compliance/noncompliance. If the Facility was not in compliance a citation was issued.[10]

The federal government owned all of the uranium until 1974, up to that time they required the uranium be returned when the fuel was spent. The Facility leased uranium from the United States, specifically the AEC. If the uranium was lost the Facility had to pay for it. This arrangement held for both commercial and government projects. Uranium was leased at a "daily lease rate," the higher the enrichment the higher the "daily lease rate." The tables to determine the "daily lease rate" were published in the Federal Register.[11]

The Facility "obtains most of its UF6 from the AEC enrichment plant at Oak Ridge, Tenn., and some from plants at Paducah, Ky., and Portsmouth, Ohio . . . The starting material generally comes in two different sized cylinders-the larger (12 inches in diameter) contains 420 pounds of UF6 and is used for all 37% or lower U235 enrichments. For UF6 containing more U235 than that amount, a smaller cylinder (5 inches in diameter)

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[8] Chester Placek, "Uranium Dioxide Nuclear Fuel." *Industrial and Engineering Chemistry*, Vol 52, no. 6, (1960), 461.

[9] James A. Rode, Deposition held at the law offices of Babst and Calland, Pittsburgh, Pennsylvania. May 9, 2002, 102.

[10] Ibid., 131-132.

[11] Ibid., 89.

containing a maximum of 55 pounds is used."[12] The Facility was supplying enriched uranium for commercial reactors and high-enrichment products for military purposes. The Facility was also contracting directly with Oak Ridge and other government contractors for the recovery of uranium from scrap materials.

The following is a list of the more sensitive projects the Facility produced fuel for:

1) The production of 93 percent enriched, high-fired UO_2 for the "Aircraft Nuclear Propulsion Project." The prime contractor was General Electric.

2) The production of nuclear fuel for the "Army Package Power Reactor Project." The reactor was small enough to be air lifted into remote areas, such as the Antarctic or on battlefields. The prime contractor is unknown.

3) The production of enriched uranium dioxide for gas-cooled reactors. The Fort St. Vrain reactor was the demonstration reactor in which the Facility provided the fuel. The prime contractors for this project were General Atomics and later Gulf General Atomics.

4) The production of uranium oxide for the NERVA project (Nuclear Rocket Project), fuel was supplied to several different contractors for this project. They included Westinghouse as the prime contractor and General Atomics as a sub-contractor.

5) The production fuel for the "Enriched Uranium Triga Reactors." These were test reactors that were supplied to educational and research institutes around the world. This was an "Atoms for Peace" project. The prime contractor was General Atomics.

6) Uranium-aluminum alloy and enriched uranium metal were produced at the Facility and then sent to New Haven, Connecticut, for fabrication of fuel elements. The fuel elements were then shipped to the Nevada test site where the Engineer Test Reactor (ETR), the Material Test Reactor (MTR), and the High Flux Intensity Reactor (HIFIR) were operated.

7) The production of 93 percent enriched uranium zirconia pellets for the LPR reactor. This was a concept for burning of fuels instead of breeder reactors in nuclear submarines. The prime contractor was Bettis Atomic Power Laboratory.

8) The Facility produced high-enrichment fuel for naval reactors, fuels were developed for reactors and propulsion reactors for naval submarines, aircraft carriers and for the D1G (Design 1st Generation) reactor which was the reactor systems used on destroyers. The prime contractor was Bettis Atomic Power Laboratory.

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[12] Chester Placek, "Uranium Dioxide Nuclear Fuel." *Industrial and Engineering Chemistry*, Vol 52, no. 6, (1960), 461.

9) Uranium was sent directly to test reactors in fifteen countries around the world as part of the "Atoms for Peace" program. The prime contractor(s) is unknown.

10) Intermediate-enrichment fuel was produced for the Nuclear Ship (NS) Savannah. The NS Savannah, a merchant ship, used to demonstrate the capabilities of nuclear propulsion for naval purposes. This project was also and "Atoms of Peace" program. The prime contractor was Babcock and Wilcox.

11) The production of fuel for the Commonwealth Edison full-scale power plant located in Dresden, Illinois. The prime contractor is unknown.

This cannot be considered a complete list of projects for which the Facility produced fuel. But the aforementioned projects clearly outline the role the Facility played in the development of nuclear fuel for not only Cold War purposes, but in the development of commercial grade nuclear energy in the United States and around the world.

By the early 1970s, under the ownership of Gulf, the plant began to cease production. Many of the contracts for high-enriched fuel product were no longer being given to the Facility. When Combustion Engineering Corporation purchased the Facility they ceased all high-enriched fuel production and focused solely on low-enrichment fuel production. At this time fuel pellets were produced and then shipped to Windsor, Massachusetts, where the pellets were inserted into fuel rods and then into bundles. This changed under the ownership of ABB. In order to make the process more cost effective and efficient, ABB decided to complete the process from pellet production to rod loading and bundle assembly in house at the Facility. As a result Building 230 was added to the complex in 1992 and Building 231 in 1993. ABB continued production of commercial grade reactor fuel until Westinghouse purchased the plant in 2000. Production continued under Westinghouse until April 2001 when all production ceased and the decommissioning of the Facility began. The final step in the decommissioning process will be to dismantle all buildings, and disposing of them in a licensed nuclear hazard waste facility.

PART II. ARCHITECTURAL HISTORY AND CONTEXT

Prior to MCW purchasing the property there was a working dairy operation. When MCW purchased the property they kept and used two of the barns. Building 101 is a modern, twentieth century barn. Its form follows the typical "Wisconsin Dairy Barn" style. The typical architectural elements for this type of barn are the gambrel roof, small symmetrical windows, triangular hay hood, roof ventilators and loft doors.[13] The unusual design element on Building 101 is the tile surround on the first story. Building 120 is also from the dairy operation. It is unknown when Building 120 was built; its form follows the

[13] Allen G. Noble and Richard K. Cleek, *The Old Barn Book: A Field Guide to North American Barns and Other Structures* (New Brunswick: Rutgers University Press, 1995), 122.

typical “English Barn” style. Typically these barns were used to store hay, feed and machinery. The barn is wood frame, wood siding, and dirt floor.

The key to understanding the architecture of the Facility is the need to control the reaction of enriched-uranium. The architectural style of the Facility can only be termed as modern industrial. Buildings 235, 240, 252, 253, 255, 256-1, and 256-2 are all constructed with 12-inch concrete block. This was necessary because the thickness acted as a barrier to keep material/product isolated from other material/product. All of these buildings had flat, rubber-coated roofs and very few doors and windows. All of these buildings were built between 1956 and 1989. Buildings 253, 256-1, and 256-2 were created in 1989, when the Combustion Engineering Corporation encapsulated the complex under one roof.

Scientists and technicians at the Facility developed a unique process for converting uranium compounds into uranium oxide granules. It was determined that the conversion process would revolutionize the industry, but that they would require more space and state of the art equipment to do the conversion on a large production scale so in 1968, Building 260 was built. The building is a four-story, steel frame with corrugated plas-steel siding.

Building 230 and 231 were built in 1992 and 1993 respectively, they are both steel framed, metal sided buildings and are of standard, modern construction. These buildings were added in order to produce the product in-house from beginning to end and ship from the Facility directly to the client.

PART III. CULTURAL LANDSCAPE COMPONENTS

Waste material was created through the process of converting the uranium. Because there were no regulations in place to dispose of the waste material and no sites prepared to receive contaminated waste, the Facility created Filtrate Disposal Ponds on site. The ponds, constructed in 1957, were originally built to receive filtrates from the low-enriched ammonium diurinate (ADU) conversion facility. These are located in the southwest corner of the Facility. There are two ponds, the first pond was the primary pond, which was 30’ x 40’. The secondary or over-flow pond was 30’ x 85’, and connected to the primary pond by an underground pipe approximately 13’ long. Both ponds were dug to a depth of 3’4”. The removed soil was used to build a berm 1-1/2’ high around both ponds. The ponds were lined with a 6” bed of 3” diameter rock, followed by a 4” bed of .5” diameter rock.

The ponds were primarily used for the disposal of low-level liquid waste containing insoluble uranium bearing precipitates and other solids. The solids would settle to the bottom of the pond and the water would eventually evaporate naturally. Materials disposed into the pond were entered into the burial log. After Combustion Engineering took over the operation of the Facility the only materials that were disposed of into the ponds were spent potassium hydroxide scrubber solution, which was created from the uranium dry recycle process, and liquids from the start-up testing of the wet recovery process. Use of the ponds was discontinued in 1978; dredging of the ponds and proper burial of the dried sludge to a licensed burial facility occurred between 1982 and 1984. Formal decommissioning and decontamination of the ponds began in 1988 but has not yet been completed.

In addition to the Filtrate Disposal Ponds the Facility also employed the use of in-ground burial pits. Westinghouse believes that the use of burial pits began being used in 1958 or 1959 in order to bury solid contaminated material. Detailed records were maintained only for the period beginning July 1965 through November 1970 when the burial of contaminated material ceased. The unlined pits were dug east of the Facility; each pit was approximately 20' x 40' x 12' deep.

On-site burial was an AEC authorized activity. The AEC regulations allowed each pit to receive up to 790 grams of highly enriched U235. Materials that were disposed of in the pits were placed in bags that prevented any leaching of the radioactivity into the soil. Between 1965 and 1970, forty pits were recorded. Westinghouse estimates that there are an additional twenty to twenty-five pits that were used prior to 1965 that were not recorded. Burials were terminated in 1970 when an AEC non-compliance citation was issued. This resulted from a May 1970 revision of the regulation that had not been implemented by UNC. The change in the regulation severely limited the Special Nuclear Material (SNM) quantity that could be buried, making on-site burial impractical.

PART IV. PROJECT INFORMATION

Methodology

The Hematite Fuel Fabrication Facility is currently undergoing mitigation due to the Westinghouse Electric Company, LLC, desire to decommission the Facility and then disassemble the buildings and structures (this is being done for safety purposes and is in accordance with federal law and regulations regarding hazardous waste clean-up and disposal). In 2003, Westinghouse Electric Company, LLC, hired SCI engineering, Inc., of St. Charles, Missouri, to complete the Historic American Engineering Record (HAER) documentation of the Facility. Dr. Steve Dasovich supervised the project. Historian Colleen Small-Vollman authored the HAER documentation report. Compilation was by Susan Sheppard. Bruce Meyer and Todd Kapler completed the necessary photographic documentation of the Facility and Asa Westphal completed the floor plan drawings.

Due to the sensitive nature of this project, research was problematic. Westinghouse is currently involved in a lawsuit that names the U.S. government and others as being, in part, responsible for contamination of the Facility site. The lawsuit has been filed under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Westinghouse made all of the documents available to the researcher with the approval of their attorney; part of the information that was made available was a series of depositions that were given by James A. Rode. Mr. Rode was an employee of MCW and was part of the planning team for the Facility. He held many different positions, including General Manager. The historian made a request to interview Mr. Rode, but Westinghouse attorneys denied that request. A request was made to view document held in the Mallinckrodt Chemical Works archive in order to view their editions of "MCW News," (a bi- monthly, internal, publication for MCW employees), that request was also denied. A 1956 edition of "MCW News" exists that discusses the Facility, an exhaustive search was conducted to locate the edition outside of MCW archive, none was located. Gaining access to the Nuclear Regulatory Commission, Region III in Lisle, Illinois, was difficult. Information regarding the Facility from 1956 through 1974 was not available, and also presented legal issues with regards to the classified status of documents necessary for the completion of this document.

Although research was difficult, there was ample information available to construct a more than adequate history for the Facility. The University of Missouri, St. Louis, Missouri, Western Historical Manuscript Collection is in possession of the Edward Mallinckrodt, Jr., Collection. The Collection spans eighty-nine years (1878-1967). In order to document changes through time aerial photographs were consulted. Oral interviews were conducted with past employees in order to determine time lines and process. Architectural drawings were made available, and as stated above, Westinghouse has made as much information as possible available.

PART IV. SOURCES OF INFORMATION

Clarfield, Gerard H., and William M. Wiecek. *Nuclear America: Military and Nuclear Power in the United States, 1940-1980.* New York: Harper & Row, 1984.

Leclercq, Jacques. *The Nuclear Age: The World of Nuclear Power Plants.* n.p. LeChene, 1986.

Malich, Phillip J. *034-JE-02 Proposed Hematite Former Fuel Processing Facility.* Missouri Department of Natural Resources, State Historic Preservation Office, Jefferson City, Missouri, 2002.

Mallinckrodt Chemical Works, Annual Report, 1956. Western Historical Manuscript Collection, University of Missouri, Saint Louis, Missouri. Collection 452, Box 42.

Mallinckrodt Chemical Works, "Hematite Revisited: The Men from Mechanical:" *Mallinckrodt Chemical Works News,* Vol. 3, no. 2 (February-March1959): 2-5.

Mallinckrodt, Jr., Edward, Collection, Western Historical Manuscripts, University of Missouri, Saint Louis, Missouri.

Noble, Allen G., and Richard K. Cleek. *The Old Barn Book: A Field Guide to North American Barns and Other Structures.* New Brunswick: Rutgers University Press, 1995.

Placek, Chester, "Industrial and Engineering Chemistry." *Mallinckrodt Nuclear* 52, no. 6 (1960): 458-464.

Rode, James A. Deposition. November 13, 2001, in Westinghouse Electric Company LLC v US and etal. Case no.4:2003cv00861. Deposition held at the law offices of Babst and Calland, Pittsburgh, Pennsylvania.

Rode, James A. Deposition. May 9, 2002, in Westinghouse Electric Company LLC v US and etal. Case no.4:2003cv00861. Deposition held at the law offices of Babst and Calland, Pittsburgh, Pennsylvania.